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JC10 Rec'd PCT/PTO 22 FEB 2002

FORM PTO-1390
(REV 10-94)

U S DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

DOCKET #: 5067-19PUS

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

U.S. APPLICATION NO. (If known, see 37 CFR 1.5)
10/069218

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/DE00/02896	**22 August 2000**	**24 August 1999**

TITLE OF INVENTION

Cylinder for a Twin-Screw Extruder

APPLICANT(S) FOR DO/EO/US

Michael BEHLING

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. [x]This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. [] This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371
3. [x]This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. [x]A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. [x]A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. [x] is transmitted herewith (required only if not transmitted by the International Bureau).
   b. [] has been transmitted by the International Bureau.
   c. [] is not required, as the application was filed in the United States Receiving Office (RO/US)
6. [x]A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. [x]Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. [] are transmitted herewith (required only if not transmitted by the International Bureau).
   b. [] have been transmitted by the International Bureau.
   c. [] have not been made; however, the time limit for making such amendments has NOT expired.
   d. [x] have not been made and will not be made.
8. [] A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. [x]An unexecuted oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. [] A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. Below concern other document(s) or information included:

11. [] An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. [] An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. [x]A **FIRST** preliminary amendment.
    [] A **SECOND** or **SUBSEQUENT** preliminary amendment.
14. [] A substitute specification.
15. [] A change of power of attorney and/or address letter.
16. [] Other items or information *(specify):* PCT Publication Sheet, Int'l Preliminary Examination Report, Int'l Search Report, PCT Request, Letter with Proposed Drawing Changes

10069218 . 062602
JC19 Rec'd PCT/PTO 22 FEB 2002

U.S. APPLICATION NO (If known, see 37 C.F.R. 1.5) 10/069218	INTERNATIONAL APPLICATION NO PCT/DE00/02896	ATTORNEY'S DOCKET NUMBER 5067-19PUS	

17.[x]The following fees are submitted:					
Basic National Fee (37 CFR 1.492(a)(1)-(5)): Search Report has been prepared by the EPO or JPO .... **$890.00** International preliminary examination fee paid to USPTO (37 CFR 1.482).......... **$710.00** No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2)) .... **$740.00** Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO .... **$1040.00** International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4).......... **$100.00**					
ENTER APPROPRIATE BASIC FEE AMOUNT =				$	890.00
Surcharge of **$130.00** for furnishing the oath or declaration later than [] 20 [] 30 months from the earliest claimed priority date (37 CFR 1.492(e)).				$	
Claims	Number Filed	Number Extra	Rate		
Total Claims	10 - 20 =	0	x **$18.00**	$	
Independent Claims	1 - 3 =	0	x **$84.00**	$	
Multiple dependent claim(s) (if applicable)			+ **$280.00**	$	
TOTAL OF ABOVE CALCULATIONS =				$	890.00
Reduction of ½ for filing by small entity, if applicable.				$	
SUBTOTAL =				$	890.00
Processing fee of **$130.00** for furnishing the English translation later than [] 20 [] 30 months from the earliest claimed priority date (37 CFR 1.492(f)). +				$	
TOTAL NATIONAL FEE =				$	890.00
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by the appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property +				$	
TOTAL FEES ENCLOSED					$890.00
				Amount to be refunded:	$
				charged:	$

a. [x] One check in the amount(s) of $ 890.00 to cover the above fees is/are enclosed.
b. [] Please charge my Deposit Account No. 03-2412 in the amount of $_____ to cover the above fees. A duplicate copy of this sheet is enclosed.
c. [x] The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 03-2412. A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:	
Thomas C. Pontani Cohen, Pontani, Lieberman & Pavane 551 Fifth Avenue, Suite 1210 New York, New York 10176	Lance J. Lieberman Registration Number: 28,437 February 22, 2002 Tel: (212) 687-2770

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By Express Mail # EL503712193US · February 22, 2002

Attorney Docket # 5067-19PUS

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re National Phase PCT Application of

Michael BEHLING

International Appln. No.: PCT/DE00/02896

International Filing Date: 22 August 2000

For: Cylinder for a Twin-Screw Extruder

PRELIMINARY AMENDMENT

Assistant Commissioner for Patents
Washington, D.C. 20231
BOX PCT

S I R:

Prior to examination of the above-identified application please amend the application as follows:

In the Specification:

On page 1, line 2, delete "Description" and insert the following headings:

--BACKGROUND OF THE INVENTION

1. Field of the Invention--

On page 1, replace the paragraph beginning on line 3 with the following:

--This invention relates to a twin-screw extruder with a cylinder surrounding the twin-screws of the extruder and a hollow cylinder mantle surrounding the cylinder.--

On page 1, before line 5, beginning a new line insert the following heading:

--**2. Description of the Prior Art**--

On page 2, replace the paragraph beginning on line 24 with the following:

--Another structure for the cylinder of a twin-screw extruder is known from DE 26 59 037 C3, which likewise consists of an inner cylinder part and a hollow-cylinder mantle. For cooling of the extrusion space, a cooling channel is provided that has a course similar in principle to a helix. The cooling channel is arranged in the region of the surface separating the inner cylinder part and the hollow-cylinder mantle. In this case it is composed of partial pieces of different shapes, in the following manner: on the upper side of the inner cylinder part, grooves are etched at equal distances from one another, with vertical walls, in such a way that the bottoms of the grooves are all parallel to the longitudinal axes of the planes in the twin-screw unit, the direction with respect to the longitudinal axis is chosen, however, at exactly the opposite angle. The arrangement of the upper and lower grooves and their distances are selected in such a way that their ends overlap pair-wise. In order to connect the overlapping ends in view of joining the tempering media, sickle-shaped connecting grooves are etched on the inner surface of the hollow-cylinder mantle. The cooling channels generated in this manner, which run like helices,

have the advantage that the tempering medium in the region of the spandrel of the spectacle-shaped hole is brought to the extrusion space relatively densely. From the viewpoint of manufacturing technology, creating of the cooling channel still requires a comparably high expense, since not only must the grooves be etched on the upper and lower side of the inner cylinder part, but etching work is also necessary on the inner side of the hollow-cylinder mantle. In addition, the hollow-cylinder mantle produced in this way is only usable for the corresponding inner cylinder part of a twin-screw extruder, but not as an inner cylinder part for a single-screw extruder.--

On page 4, replace the paragraph beginning on line 6 with the following:

--Another solution for a cylinder of a twin-screw extruder that has an inner cylinder part and a hollow-cylinder mantle surrounding it is known from DE-OS 20 61 700, which is the overall state of the art. The wall of the inner cylinder part is cut through with numerous adjacent grooves above, below, and to the side of the spectacle-shaped hole for the twin-screw unit. The bottoms of these grooves run in straight-line segments or in arcs in such a way that the remaining wall to the extrusion space has approximately the same thickness everywhere. This requires a correspondingly high manufacturing cost. In order for connect the individual grooves into a channel running like a helix for the cooling medium, the grooves on the bottom side of the inner cylinder part are connected together in such a way that three partial pieces, two of which run perpendicular to the longitudinal axis of the twin-screw unit and a middle one is directed at an angle to the longitudinal axis, in such a way that an overflow from

one winding of the cooling channel to the next results. This in turn leads to an increase in manufacturing costs for the inner cylinder part. Since walls (bridges) remaining between the individual windings of the cooling channel should serve to transfer loads to the hollow-cylinder mantle that surrounds the inner cylinder part, the bridges, which have relatively small dimensions, arranged above and below the spectacle-shaped hole of the extrusion space and were originally especially high, are etched on a surface parallel to the plane of the twin-screw unit. On this etched surface, the bridges are each made in a cylinder section formed from filling material on the upper side and on the lower side of the inner cylinder part, the outer contour of the cylinder section corresponding to the hollow-cylinder mantle. These cylinder sections cover the individual windings of the cooling channels from top to bottom. In this way, the cross-section of the cooling channel, when viewed from above the circumference, remains approximately uniform in size. Although this known construction makes it possible to use a hollow-cylinder mantle with a smooth inner surface, it not only requires an increased manufacturing cost to generate the individual winding of the cooling channel, but also an additional cost for creating the two cylinder segments.--

On page 5, after line 20, beginning its own line insert the following heading:

--**SUMMARY OF THE PRESENT INVENTION**--

On page 5, replace the paragraph beginning on line 21 with the following:

--The object of the present invention is to develop a cylinder for a twin-screw extruder so that the manufacturing cost required remains as small as possible, whereby an especially uniform and effective tempering of the extrusion space is to be provided. In addition, the hollow-cylinder mantle of the cylinder should be usable universally, as far as possible. Specifically, it should be usable for single-screw as well as twin-screw extruders.--

On page 6, delete lines 5-7 in their entirety and insert the following therefore:

--The object of the present invention is met by a cylinder assembly for a twin-screw extruder having a cylinder with a variable wall thickness which defines an extrusion space for receiving twin screws of the twin-screw extruder. A hollow-cylinder mantle surrounds the cylinder. At least one channel having a helical shape and a cycle depth is formed on an outer side of the cylinder by a winding vortex process. An inlet and outlet are formed in the hollow-cylinder mantle in communication with the at least one channel for allowing a flow of a tempering medium from the inlet to the outlet via the at least one channel. The hollow-cylinder mantle closes the at least one channel. The cycle depth of the at least one channel varies along the circumferential direction of the cylinder such that the cycle depth is largest in regions where the wall thickness of the cylinder is largest and the cycle depth is smallest in regions where the wall thickness of the cylinder is smallest.--

On page 6, replace the paragraph beginning on line 8 with the following:

--The present invention starts from a twin-screw extruder with a cylinder, which surrounds the twin-screw of the extruder, forming an extrusion space. The cylinder is surrounded in turn by a hollow-cylinder mantle, the inner surface of which is made smooth. On the outer side of the cylinder, at least one channel is built in, which extends in the form of a helix in the longitudinal direction of the cylinder and can be connected for conducting a tempering medium. In the state of the art, the channel formed as a helix is closed in the radial direction through a part of the cylinder by separately produced cylinder sections, while the corresponding connection in the other regions of the circumference are closed directly by the hollow-cylinder mantel. In contrast the channels in the cylinder constructed according to the invention is/are closed over the entire circumference by the hollow-cylinder mantel itself. Thus no components are needed that correspond to the cylinder sections from the overall state of the art. A significant cost reduction for the cylinder according to the invention results from the circumstance that the channel(s) for the tempering medium are generated by a winding vortex. This involves an especially simple manufacturing process that can be implemented by placing the piece under tension and generating channels with a completely uniform helical course, which is a great advantage for the flow-through of the tempering medium. The channel(s) thus have no sudden kinks or other flow obstacles.--

On page 7, replace the paragraph beginning on line 11 with the following:

--In principle, the cylinder can be provided with a single channel with a helical shape. In most cases, however, it will be appropriate, such as with multiple windings, to provide several channels next to one other. Advantageously, there will be three or four such channels running parallel to one another on the outside of the cylinder. The pitch of the channel(s) will generally be kept constant over the length of the cylinder. In individual cases, however, it may be reasonable to change this pitch, in order to affect the dwell time of the tempering medium in a particular section of the cylinder along its longitudinal axis. By selecting a large pitch, the tempering medium can be fed in the direction in which the extruder moves or even in the opposite direction, as needed.--

On page 8, repalce the paragraphs beginning on lines 1 and 20 with the following:

--In many cases, a rectangular shape may be provided for the channel(s). The depths of each channel in the radial direction, i.e. its cycle depth, may remain constant over the circumference of the cylinder. The advantage is that the wall thickness of the extrusion space is likewise constant over the circumference and thus the flow patch through the wall of the extrusion space for the heat to be transported -- seen over the circumference -- likewise remains constant. In regard to the arrangement of the individual windings of the channel(s) of the cylinder, it has turned out to be appropriate, especially with channels with a rectangular cross-section and a uniform cycle depth, that the width of the channel(s)(measured in the longitudinal direction of the cylinder) be set at in the region of the 0.7 to 1.2 times the thickness of the bridges between channels. The bridges are dimensioned in such a way that they provide directly an

adequate support for load transfer to the hollow-cylinder mantle, without special components such as are needed in the cylinder section according to DE-OS 2,061,700.--

--In an embodiment of the present invention, a design of the channel(s) with various cycle depths is provided over the circumferences. In this case, the cycle depth is selected as small as possible in the regions where the original wall thickness of the cylinder, i.e. the thickness before the channels are made, is smallest. The greatest cycle depth is provided in the regions in which the original wall thickness is greatest. The transition between the largest and smallest cycle depths run completely smoothly and uniformly, because of the winding-vortex process envisioned for producing the channels. For a twin-screw extruder, a cylinder is recommended in which the largest cycle depth of the channel is about 3 to 5 times the smallest cycle depth, especially preferably about 4 times. In this case it may be appropriate to select something other than a rectangular shape and provide a conic expansion in the outward direction for the cross-section in the radial direction. The width of each channel thus increases in the outward direction. This means that the side surfaces of each channel in the section through the length of the cylinder do not run parallel, but include an angle, α. This angle, α, is advantageously in the range of 8-15°, especially about 10°. With a conic shape for the cross-section of the channels, it is recommended that the average thickness of the bridges between each pair of adjacent windings in the channel(s) be selected in the range of 1.5 to 4 times the average width of the channel(s). An average bridge width of about 2.5 times the average channel width is preferred.--

On page 10, replace the paragraph beginning on line 9 with the following:

--Beyond the low manufacturing costs, the cylinder according to the present invention provides an effective heat exchange, since through the effect of the cycle depth of the channels the flow path for the heat can be reduced within the wall of the cylinder as needed. Increased resistances to the flow of heat due to separation surfaces between individual components are avoided in the invention. For a given cylinder diameter, it makes no difference for the design of the hollow-cylinder mantle surrounding the cylinder how many channels, with which cross-section shape, and which cycle depths are provided in the cylinder.--

On page 10, delete lines 20-22 in their entirety and insert the following therefore:

--**<u>BRIEF DESCRIPTION OF THE DRAWINGS</u>**

In the drawings wherein like reference characters denote similar elements throughout several views:--

On page 11, replace the paragraph beginning on line 1 with the following:

--Fig. 1 is a perspective view of a cylinder according to an embodiment of the invention;

Fig. 2 is a view from the right front side of the cylinder according to Fig. 1;

Fig. 3 is a longitudinal section along line III-III in Fig. 2;

Fig. 4 is a longitudinal section along line IV-IV in Fig. 2;

Fig. 5 is a cross-section along line V-V in Fig. 3;

Fig. 6 is a view of the left front side of the cylinder according to Fig. 1; and

Fig. 7 is the cylinder according to Fig. 1 inserted into a cylindrical mantle in a partial side view and partial longitudinal section.--

On page 11, after line 14, beginning its own line, insert the following heading:

--**DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT**--

On page 11, replace the paragraph beginning on line 15 with the following:

--A cylinder 1 shown in perspective in Fig. 1 is provided for an extruder with a twin-screw unit and therefore has two partially overlapping holes for the two meshed screws (not shown), whereby the holes together form an extrusion space 2 with a cross-section in the shape of spectacles. An application flange 14 in the region of the front side of the cylinder 1 (on the left side in Fig. 1), has a diameter that is only slighter larger than that of the remainder of the length of the cylinder. On the outer side of the cylinder 1, a number of windings of channels 3 are provided in the shape of a helix, between which bridges 4 stand as separation walls.--

On page 12, replace the paragraph beginning on line 2 with the following:

--The implementation of the channels 3 can be seen in detail from the section views of Figs. 3 through 5. The axial longitudinal section in Fig. 3 shows that the channels 3 each have side walls 5, 6 that are at an angle α to each other, so that the channel width expands conically outward in the radial direction. The average width of the bridges 4 between the individual windings of the channels 3 is about 2 to 2½ times the average width of the channels 3

(measured in the longitudinal direction of the cylinder 1). It can be seen from Fig. 5 that a total of four channels are involved here, which extend at equal distances from each other in a helical shape over the axial length of the cylinder 1. It can also be seen from Fig. 5 that the cycle depth of the channels 3, i.e. the radial depth, is not constant over the course of the circumference of the cylinder 1, but changes uniformly in the region near the planes through the longitudinal axis of the extrusion space 2, in which the cycle depth in the channels 3, indicated by h_2, is the greatest. The uniform change of the cycle depth between the largest value, h_2, and the smallest value, h_1, results in a simple manner from a corresponding setting of the process parameters used in the winding vortex process used in producing the channels 3. Whereas Fig. 3 shows a side view and a longitudinal cross-section in the region of the smallest cycle depth, h_2, in Fig. 4 a longitudinal section is shown, rotated by 90° i.e., in the region of the smallest cycle depth. By varying the cycle depth over the circumference of the cylinder 1, extreme differences in heat flow between the extrusion space 2 and the channels 3 over the circumference of the cylinder 1 are greatly reduced. Each of the four channels 3 opens into a groove 7, 8 that respectively runs around and near to the end of the cylinder 1. The grooves 7, 8 act as a distributor and a collector for the tempering fluid to be fed through the channels 3.--

On page 13, replace the paragraph beginning on line 15 with the following:

--In Fig. 6, a view of the front side of the cylinder 1 is shown with the application flange 14. As can also be seen in Fig. 2, holes to accept adjusting bolts 15 are provided in the region of the greatest wall thickness. (The adjusting bolts are shown in detail in the side view of Fig. 7). A complete cylinder assembly 11, consisting of the cylinder 1 and the associated

hollow-cylinder mantel 10, in halves in the longitudinal section, is shown in Fig. 7 . The hollow-cylinder mantle 10, which has connecting flanges 17, 18 on each of its two ends, has a smooth inner surface. Only in the region of the application flange 14 does it have a section with an enlarged inner diameter, which corresponds to the outer diameter of the application flange 14 of the cylinder 1, so that the application flange 14 can be applied in this section and be held as a stop against shifts by the cylinder 1 in the longitudinal direction. The inner diameter of the hollow-cylinder mantle 10 corresponds to the outer diameter of the bridges 4 of the cylinder 1, which is thus embedded as a "moist bushing" in the hollow-cylinder mantle 10, so that the individual windings of the channels 3 are closed in the radial direction toward the outside. There is a radial hole through the connection surfaces 17, 18 for feeding the intake 12 and the outlet 13 of the tempering medium, which end in the region of the circumferential grooves 7, 8. The connection between the circumferential groove 8 and the outlet 13 is not as direct as between the circumferential groove 7 and the intake 12. Rather, the connection is made in this case through an indentation 19 in the application flange 14. The tempering medium can thus flow through the intake 12 in the circumferential groove 7, which functions as a distributor, and from there into the four channels 3 in the shape of a screw line. After flowing through the channels 3, the tempering medium arrives at the circumferential channel 8, which functions as a collector and is there again removed through the indentation 19 and the line 13 from the full cylinder assembly 11. During the flow through the channels 3, an effective heat exchange takes place between the tempering medium and the extrusion space 2.--

On page 15, replace the paragraph beginning on line 2 with the following:

--To prevent the cylinder 1 from turning with respect to the hollow-cylinder mantle 11, stop grooves 9 are provided in the region of the circumference of the application flange 14, into which pin screws 16 make contact through corresponding holes made radially through the connection flange 18. Through the connection flanges 17, 18, several full cylinder assemblies 11 can be connected together. In this case it is obviously possible, with a hollow-cylinder mantle 10 of unchanged construction with respect to the channels, to use various cylinders 1, in order to meet optimally the different needs for heat exchange (cooling or heating) along the extrusion space.--

Delete page 16 in its entirety.

In the Claims:

Delete claims 1-10 and insert new claims 11-20:

11. (New) A cylinder assembly for a twin-screw extruder, comprising a cylinder having a variable wall thickness defining an extrusion space for receiving twin screws of the twin-screw extruder and a hollow-cylinder mantle surrounding the cylinder, wherein at least one channel having a helical shape and a cycle depth is formed on an outer side of the cylinder by a winding vortex process and an inlet and outlet are formed in the hollow-cylinder mantle in communication with the at least one channel for allowing a flow of a tempering medium from the inlet to the outlet via the at least one channel, the hollow-cylinder mantle closing the at least

one channel, and wherein the cycle depth of the at least one channel varies along the circumferential direction of the cylinder such that the cycle depth is largest in regions where the wall thickness of the cylinder is largest and the cycle depth is smallest in regions where the wall thickness of the cylinder is smallest.

12. (New) The cylinder assembly of claim 11, wherein said at least one channel comprises a plurality of channels.

13. (New) The cylinder assembly of claim 11, wherein a pitch of said channels along a longitudinal direction of the cylinder is constant.

14. (New) The cylinder assembly of claim 11, wherein the at least one channel comprises a rectangular cross-section.

15. (New) The cylinder assembly of claim 11, wherein the cylinder also forms bridges between adjacent windings of the at least one channel having a width in the longitudinal direction, the width of the channel being in the range including 0.7 to 1.2 times the width of the bridge.

16. (New) The cylinder assembly of claim 11, wherein the at least one channel has a variable cycle depth having a largest cycle depth and a smallest cycle depth, the largest cycle depth being within the range of 3 to 5 times the smallest cycle depth.

17. (New) The cylinder assembly of claim 11, wherein the at least one channel has side walls arranged so that the width of the at least one channel increases from a radially inner portion to a radially outer portion of the at least one channel.

18. (New) The cylinder assembly of claim 17, wherein the side walls are arranged at an angle relative to one another, the angle being within the range including 8-15 degrees.

19. (New) The cylinder assembly of claim 11, wherein the cylinder also forms bridges between adjacent windings of the at least one channel, wherein an average thickness of the bridges between two adjacent windings of the at least one channel is in the rage of 1.5 to 4 times the average width of the channels.

20. (New) The cylinder assembly of claim 11, wherein said cylinder further comprises circumferential grooves respectively arranged proximate opposing ends of the cylinder such that said at least one channels opens into said circumferential grooves, and each of the inlet and outlet in the hollow-cylinder mantle open into one of the circumferential grooves.

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In the Abstract:

Amend the abstract as follows:

--A cylinder assembly for a twin-screw extruder includes a cylinder forming an extrusion space and a hollow-cylinder mantle surrounding the cylinder and having a smooth inner surface. At least one channel is made in the shape of a helix in the longitudinal direction on the outside of the cylinder. The at least one channel is connected to an intake and outlet for conducting a tempering medium. The at least one channel is made by a winding-vortex process and the at least one channel is closed by the hollow-cylinder mantle. The cycle depth of the at least one channel in the radial direction changes over the circumference of the cylinder such that it is greatest in regions where the original wall thickness of the cylinder is greatest, and that it is smallest in the regions where the original wall thickness of the cylinder is also smallest.--

REMARKS

This preliminary amendment is presented to place the application in proper form for examination and to eliminate multiple dependency from the present claims. No new matter has been added. Early examination and favorable consideration of the above-identified application is earnestly solicited.

Any additional fees or charges required at this time in connection with the application may be charged to our Patent and Trademark Office Deposit Account No. 03-2412.

Respectfully submitted,
COHEN, PONTANI, LIEBERMAN & PAVANE

By: ______________________

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AMENDMENTS TO THE SPECIFICATION AND CLAIMS SHOWING CHANGES

In the Specification:

On page 1, line 2, delete "Description" and insert the following headings:

--BACKGROUND OF THE INVENTION

1. Field of the Invention--

On page 1, amend the paragraph beginning on line 3 as follows:

--This invention [concerns] relates to a twin-screw extruder [according to the main concept of patent claim 1] with a cylinder surrounding the twin-screws of the extruder and a hollow cylinder mantle surrounding the cylinder.--

On page 1, before line 5, beginning a new line insert the following heading:

--**2. Description of the Prior Art**--

On page 2, amend the paragraph beginning on line 24 as follows:

--Another structure for the cylinder of a twin-screw extruder is known from DE 26 59 037 C3, which likewise consists of an inner cylinder part and a hollow-cylinder mantle. For cooling of the extrusion space, a cooling channel is provided that has a course similar in principle to a [screw line] helix. The cooling channel is arranged in the region of the surface separating the inner cylinder part and the hollow-cylinder mantle. In this case it is composed of partial pieces of different shapes, in the following manner: on the upper side of the inner cylinder

part, grooves are etched at equal distances from one another, with vertical walls, in such a way that the bottoms of the grooves are all parallel to the longitudinal axes of the planes in the twin-screw unit, the direction with respect to the longitudinal axis is chosen, however, at exactly the opposite angle. The arrangement of the upper and lower grooves and their distances are selected in such a way that their ends overlap pair-wise. In order to connect the overlapping ends in view of joining the tempering media, sickle-shaped connecting grooves are etched on the inner surface of the hollow-cylinder mantle. The cooling channels generated in this manner, which run like [screw lines] <u>helices</u>, have the advantage that the tempering medium in the region of the spandrel of the spectacle-shaped hole is brought to the extrusion space relatively densely. From the viewpoint of manufacturing technology, creating of the cooling channel still requires a comparably high expense, since not only must the grooves be etched on the upper and lower side of the inner cylinder part, but etching work is also necessary on the inner side of the hollow-cylinder mantle. In addition, the hollow-cylinder mantle produced in this way is only usable for the corresponding inner cylinder part of a twin-screw extruder, but not as an inner cylinder part for a single-screw extruder.--

On page 4, amend the paragraph beginning on line 6 as follows:

--Another solution for a cylinder of a twin-screw extruder that has an inner cylinder part and a hollow-cylinder mantle surrounding it is known from DE-OS 20 61 700, which is the overall state of the art. The wall of the inner cylinder part is cut through with numerous adjacent grooves above, below, and to the side of the spectacle-shaped hole for the

twin-screw unit. The bottoms of these grooves run in straight-line segments or in arcs in such a way that the remaining wall to the extrusion space has approximately the same thickness everywhere. This requires a correspondingly high manufacturing cost. In order for connect the individual grooves into a channel running like a [screw line] helix for the cooling medium, the grooves on the bottom side of the inner cylinder part are connected together in such a way that three partial pieces, two of which run perpendicular to the longitudinal axis of the twin-screw unit and a middle one is directed at an angle to the longitudinal axis, in such a way that an overflow from one winding of the cooling channel to the next results. This in turn leads to an increase in manufacturing costs for the inner cylinder part. Since walls (bridges) remaining between the individual windings of the cooling channel should serve to transfer loads to the hollow-cylinder mantle that surrounds the inner cylinder part, the bridges, which have relatively small dimensions, arranged above and below the spectacle-shaped hole of the extrusion space and were originally especially high, are etched on a surface parallel to the plane of the twin-screw unit. On this etched surface, the bridges are each made in a cylinder section formed from filling material on the upper side and on the lower side of the inner cylinder part, the outer contour of the cylinder section corresponding to the hollow-cylinder mantle. These cylinder sections cover the individual windings of the cooling channels from top to bottom. In this way, the cross-section of the cooling channel, when viewed from above the circumference, remains approximately uniform in size. Although this known construction makes it possible to use a hollow-cylinder mantle with a smooth inner surface, it not only requires an increased manufacturing cost to generate the individual winding of the cooling channel, but also an additional cost for creating the two cylinder segments.--

On page 5, after line 20, beginning its own line insert the following heading:

--**SUMMARY OF THE PRESENT INVENTION**--

On page 5, amend the paragraph beginning on line 21 as follows:

--The [task] object of the present invention is to develop a cylinder [according to the overall concept of patent claim 1] for a twin-screw extruder so that the manufacturing cost required remains as small as possible, whereby an especially uniform and effective tempering of the extrusion space is to be provided. In addition, the hollow-cylinder mantle of the cylinder should be usable universally, as far as possible. Specifically, it should be usable for single-screw as well as twin-screw extruders.--

On page 6, delete lines 5-7 in their entirety and insert the following therefore:

--The object of the present invention is met by a cylinder assembly for a twin-screw extruder having a cylinder with a variable wall thickness which defines an extrusion space for receiving twin screws of the twin-screw extruder. A hollow-cylinder mantle surrounds the cylinder. At least one channel having a helical shape and a cycle depth is formed on an outer side of the cylinder by a winding vortex process. An inlet and outlet are formed in the hollow-cylinder mantle in communication with the at least one channel for allowing a flow of a tempering medium from the inlet to the outlet via the at least one channel. The hollow-cylinder mantle closes the at least one channel. The cycle depth of the at least one channel varies along

the circumferential direction of the cylinder such that the cycle depth is largest in regions where the wall thickness of the cylinder is largest and the cycle depth is smallest in regions where the wall thickness of the cylinder is smallest.--

On page 6, amend the paragraph beginning on line 8 as follows:

--The present invention starts from a twin-screw extruder with a cylinder, which surrounds the twin-screw of the extruder, forming an extrusion space. The cylinder is surrounded in turn by a hollow-cylinder mantle, the inner surface of which is made smooth. On the outer side of the cylinder, at least one channel is built in, which extends in the form of a [screw line] helix in the longitudinal direction of the cylinder and can be connected for conducting a tempering medium [that can flow]. In [contrast to the overall] the state of the art, [in which] the channel [in the form of a screw line] formed as a helix is closed in the radial direction through a part of the cylinder by separately produced cylinder sections, while the corresponding connection in the other regions of the circumference are closed directly by the hollow-cylinder mantel[, in] . In contrast the channels in the cylinder constructed according to the invention[, it is envisioned that the channel(s)] is/are closed over the entire circumference by the hollow-cylinder mantel itself. Thus no components are needed that correspond to the cylinder sections from the overall state of the art. A significant cost reduction for the cylinder according to the invention results from the circumstance that the channel(s) for the tempering medium are generated by a winding vortex. This involves an especially simple manufacturing process that can be implemented by placing the piece under tension and generating channels with a completely uniform [screw-line]

helical course, which is a great advantage for the flow-through of the tempering medium. The channel(s) thus have no sudden kinks or other flow obstacles.--

On page 7, amend the paragraph beginning on line 11 as follows:

--In principle, the cylinder can be provided with a single channel with a [screw-line] helical shape. In most cases, however, it will be appropriate, such as with multiple windings, to provide several channels next to one other. Advantageously, there will be three or four such channels running parallel to one another on the outside of the cylinder. The pitch of the channel(s) will generally be kept constant over the length of the cylinder. In individual cases, however, it may be reasonable to change this pitch, in order to affect the dwell time of the tempering medium in a particular section of the cylinder along its longitudinal axis. By selecting a large pitch, the tempering medium can be fed in the direction in which the extruder moves or even in the opposite direction, as needed.--

On page 8, amend the paragraphs beginning on lines 1 and 20 as follows:

--In many cases, [it is advantageous to provide] a rectangular shape may be provided for the channel(s). The depths of each channel in the radial direction, i.e. its cycle depth, [can] may remain constant over the circumference of the cylinder. The advantage is that the wall thickness of the extrusion space is likewise constant over the circumference and thus the flow patch through the wall of the extrusion space for the heat to be transported -- seen over the circumference -- likewise remains constant. In regard to the arrangement of the individual

windings of the channel(s) of the cylinder, it has turned out to be appropriate, especially with channels with a rectangular cross-section and a uniform cycle depth, that the width of the channel(s)(measured in the longitudinal direction of the cylinder) be set at in the region of the 0.7 to 1.2 times the thickness of the bridges [of the] between channels. The bridges are dimensioned in such a way that they provide directly an adequate support for load transfer to the hollow-cylinder mantle, without special components such as are needed in the cylinder section according to DE-OS 2,061,700.--

--In [the] an embodiment of the present invention, a design of the channel(s) with various cycle depths is provided over the circumferences. In this case, the cycle depth is selected as small as possible in the regions where the original wall thickness of the cylinder, i.e. the thickness before the channels are made, is smallest. The greatest cycle depth is provided in the regions in which the original wall thickness is greatest. The transition between the largest and smallest cycle depths run completely smoothly and uniformly, because of the winding-vortex process envisioned for producing the channels. For a twin-screw extruder, a cylinder is recommended in which the largest cycle depth of the channel is about 3 to 5 times the smallest cycle depth, especially preferably about 4 times. In this case it may be appropriate to select something other than a rectangular shape and provide a conic expansion in the outward direction for the cross-section in the radial direction. The width of each channel thus increases in the outward direction. This means that the side surfaces of each channel in the section through the length of the cylinder do not run parallel, but include an angle, α. This angle, α, is advantageously in the range of 8-15°, especially about 10°. With a conic shape for the cross-

section of the channels, it is recommended that the average thickness of the bridges between each pair of adjacent windings in the channel(s) be selected in the range of 1.5 to 4 times the average width of the channel(s). An average bridge width of about 2.5 times the average channel width is preferred.--

On page 10, amend the paragraph beginning on line 9 as follows:

--Beyond the low manufacturing costs, the cylinder according to the present invention provides an effective heat exchange, since through the effect of the cycle depth of the channels the flow path for the heat can be reduced within the wall of the cylinder as needed. Increased resistances to the flow of heat due to separation surfaces between individual components are avoided in the invention. For a given cylinder diameter, it makes no difference for the design of the hollow-cylinder mantle surrounding the cylinder how many channels, with which cross-section shape, and which cycle depths are provided in the cylinder.--

On page 10, delete lines 20-22 in their entirety and insert the following therefore:

--**BRIEF DESCRIPTION OF THE DRAWINGS**

In the drawings wherein like reference characters denote similar elements throughout several views:--

On page 11, amend the paragraph beginning on line 1 as follows:

-- Fig. 1 [shows] is a perspective view of a cylinder according to an embodiment of the invention[,] ;

Fig. 2 [shows] is a view from the right front side of the cylinder according to Fig. 1[,] ;

Fig. 3 [shows] is a longitudinal section along line [A-A] III-III in Fig. 2[, presenting a view of the upper half,] ;

Fig. 4 [shows] is a longitudinal section along line [B-B] IV-IV in Fig. 2[, presenting a view of the lower half,] ;

Fig. 5 [shows] is a cross-section along line [C-C] V-V in Fig. 3[,];

Fig. 6 [shows] is a view of the left front side of the cylinder according to Fig. 1[,] ; and

Fig. 7 [shows] is the cylinder according to Fig. 1 inserted into a cylindrical mantle in a partial side view and partial longitudinal section.--

On page 11, after line 14, beginning its own line, insert the following heading:

--**DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT**--

On page 11, amend the paragraph beginning on line 15 as follows:

-- [The] A cylinder 1 shown in perspective in Fig. 1 is provided for an extruder with a twin-screw unit and therefore has two partially overlapping holes for the two meshed screws (not shown), whereby the holes together form an extrusion space 2 with a cross-section in the shape of spectacles. [In] An application flange 14 in the region of the [left] front side of the cylinder 1 (on the left side in Fig. 1), [an application flange 14 is provided, which, as can be seen especially in Figs. 3 and 4,] has a diameter that is only slighter larger than that of the [cylinder 1

in the rest] remainder of [its] the length of the cylinder. On the outer side of the cylinder 1, a number of windings of channels 3 are provided in the shape of a [screw line] helix, between which bridges 4 stand as separation walls.--

On page 12, amend the paragraph beginning on line 2 as follows:

--The implementation of the channels 3 can be seen in detail from the section views of Figs. 3 through 5. The axial longitudinal section in Fig. 3 [along line A-A according to Fig. 2] shows that the channels 3 each have side walls 5, 6 that are at an angle[,] α[,] to each other, so that the channel [cross-section] width expands conically outward in the radial direction. The average width of the bridges 4 between the individual windings of the channels 3 is about 2 to 2½ times the average width of the channels 3(measured in the longitudinal direction of the cylinder 1). It can be seen from [the cross-section made along line C-C according to Fig. 3, which is shown in] Fig. 5[,] that a total of four channels are involved here, which extend at equal distances from each other in [the] a helical shape [of a screw line] over the [essential part of] the axial length of the cylinder 1. It can also be seen from Fig. 5 that the cycle depth of the channels 3, i.e. [their] the radial depth [in the radial direction of the cylinder 1], is not constant over the course of the circumference of the cylinder 1, but changes uniformly in the region near the planes through the longitudinal axis of the extrusion space 2, in which the cycle depth in the channels 3, indicated by h_2, is the greatest. The uniform change of the cycle depth between the largest value, h_2, and the smallest value, h_1, results in a simple manner from a corresponding setting of the process parameters used in the winding vortex process used in producing the channels 3. Whereas Fig. 3 shows a side view and a longitudinal cross-section in the region of

the smallest cycle depth, h_2, in Fig. 4 a longitudinal section [along line B-B] is shown, rotated by 90° i.e., in the region of the smallest cycle depth. By varying the cycle depth over the circumference of the cylinder 1, [it is achieved that] extreme differences in heat flow between the extrusion space 2 and the channels 3 over the circumference of the cylinder 1 are greatly reduced. Each of the four channels 3 opens into a groove 7, [or] 8 that respectively runs around and near to the [front] end of the cylinder 1[, which has the function of]. The grooves 7, 8 act as a distributor [or] and a collector for the tempering fluid to be fed through the channels 3.--

On page 13, amend the paragraph beginning on line 15 as follows:

--In Fig. 6, a view of the front side of the cylinder 1 is shown with the application flange 14. As can also be seen in Fig. 2, holes to accept adjusting bolts 15 are provided in the region of the greatest wall thickness[, which] (The adjusting bolts are shown in detail in the side view of Fig. 7). [Fig. 7 shows the structure of a] A complete cylinder assembly 11, consisting of the cylinder 1 and the associated hollow-cylinder mantel 10, in halves in the longitudinal section , is shown in Fig. 7 . The hollow-cylinder mantle 10, which has connecting flanges 17, 18 on each of its two ends, [is made] has a smooth [on its] inner surface. Only in the region of the application flange 14 does it have a section with an enlarged inner diameter, which corresponds to the outer diameter of the application flange 14 of the cylinder 1, so that the application flange 14 can be applied in this section and be held as a stop against shifts by the cylinder 1 in the longitudinal direction. The inner diameter of the hollow-cylinder mantle 10 corresponds to the outer diameter of the bridges 4 of the cylinder 1, which is thus embedded as a "moist bushing" in the hollow-cylinder mantle 10, so that the individual windings of the channels 3 are closed in the

radial direction toward the outside. There is a radial hole through the connection surfaces 17, 18 for feeding the intake 12 and the outlet 13 of the tempering medium, which end in the region of the circumferential grooves 7, 8. The connection between the circumferential groove 8 and the outlet 13 is not as direct as between the circumferential groove 7 and the intake 12. Rather, the connection is made in this case through an indentation 19 in the application flange 14. The tempering medium can thus flow through the intake 12 in the circumferential groove 7, which functions as a distributor, and from there into the four channels 3 in the shape of a screw line. After flowing through the channels 3, the tempering medium arrives at the circumferential channel 8, which functions as a collector and is there again removed through the indentation 19 and the line 13 from the full cylinder assembly 11. During the flow through the channels 3, an effective heat exchange takes place between the tempering medium and the extrusion space 2.--

On page 15, amend the paragraph beginning on line 2 as follows:

--[Because] To prevent the cylinder 1 [cannot be turned] from turning with respect to the hollow-cylinder mantle 11, stop grooves 9 are provided in the region of the circumference of the application flange 14, into which pin screws 16 make contact through corresponding holes made radially through the connection flange 18. Through the connection flanges 17, 18, several full [cylinders] cylinder assemblies 11 can be connected together. In this case it is obviously possible, with a hollow-cylinder mantle 10 of unchanged construction with respect to the channels, to use various cylinders 1, in order to meet optimally the different needs for heat exchange (cooling or heating) along the extrusion space.--

By Express Mail # EL503712193US · February 22, 2002

In the Abstract:

Please amend the Abstract as follows:

--[The invention concerns a] A cylinder assembly for a twin-screw extruder[, where] includes a cylinder [the cylinder (1) surrounds a twin screw of the extruder,] forming an extrusion space [(2)] and [is in turn surrounded by] a hollow-cylinder mantle surrounding the cylinder [(10), which has] and having a smooth inner surface[,] . [where on the outside of the cylinder (1) at] At least one channel [(3)] is made in the shape of a [screw line] helix in the longitudinal direction on the outside of the cylinder [(1),] . [which can be] The at least one channel is connected to an intake and outlet [(12, 13)] for conducting a tempering medium [that is capable of flowing, and can be closed, at least over part of the circumference of the cylinder (1), in the radial direction by the hollow-cylinder mantle (10). In this case,] The at least one channel [(3)] is made [in the cylinder (1)] by a winding-vortex process and the at least one channel[(s) (3) [are]] is closed by the hollow-cylinder mantle [(10)]. The cycle depth of the at least one channel[(s) (3)] in the radial direction changes over the circumference of the cylinder [(1) in] such [a way] that it is greatest in regions where the original wall thickness of the cylinder [(1)] is greatest, and that it is smallest in the regions where the original wall thickness of the cylinder [(1)] is also smallest.

[Figure 1 attached.]

By Express Mail No. EL503712193US February 22, 2002

Attorney Docket # 5067-19PUS

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re National Phase PCT Application of

Michael BEHLING et al.

International Appln. No.: PCT/DE00/02896

International Filing Date: 22 August 2000

For: Cylinder for a Twin-Screw Extruder

LETTER WITH PROPOSED DRAWING CHANGES

Assistant Commissioner for Patents
Washington, D.C. 20231
BOX PCT

S I R:

Please admit the attached proposed correction to Figs. 2 and 3. The attached copies of Figs. 2 and 3 show the proposed corrections in red. The proposed corrections change the line numbers for the cross-section references so that the cross-section reference lines correspond to the Figure which shows the cross-section.

By Express Mail # EL503712193US · February 22, 2002

It is believed that no additional fees or charges are required at this time in connection with the above-identified application; however, if any fees or charges are required at this time in connection with the application, they may be charged to our Patent and Trademark Office Deposit Account No. 03-2412.

Respectfully submitted,
COHEN, PONTANI, LIEBERMAN & PAVANE

By: ______________________

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Reg. No. 28,437
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New York, N.Y. 10176
(212) 687-2770

22 February 2002

Enclosures: Proposed drawings

Fig.1

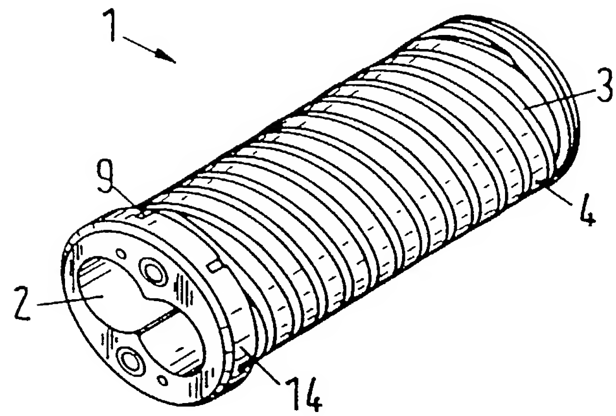

Fig.2

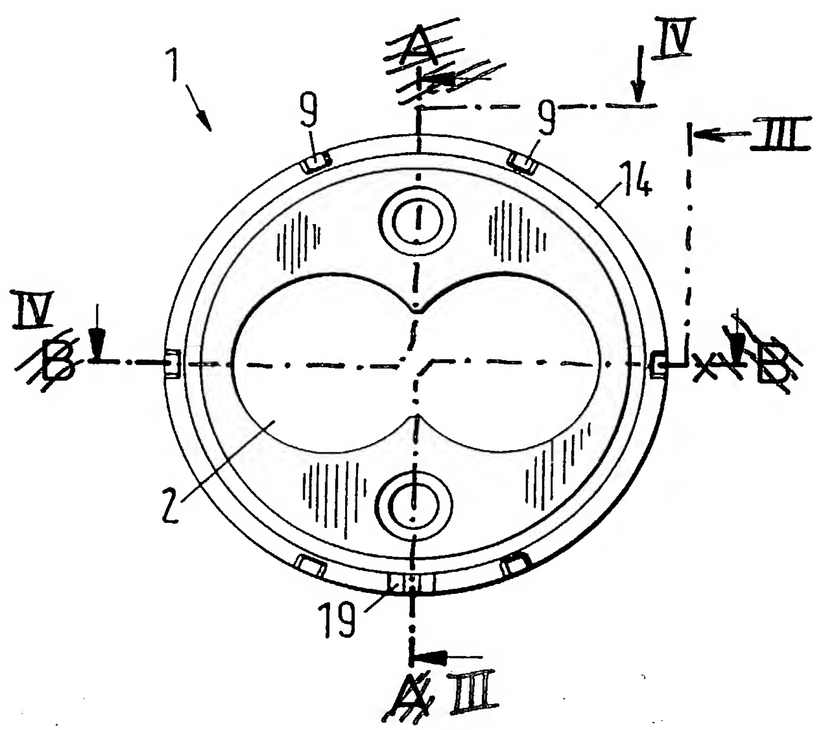

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Fig.3

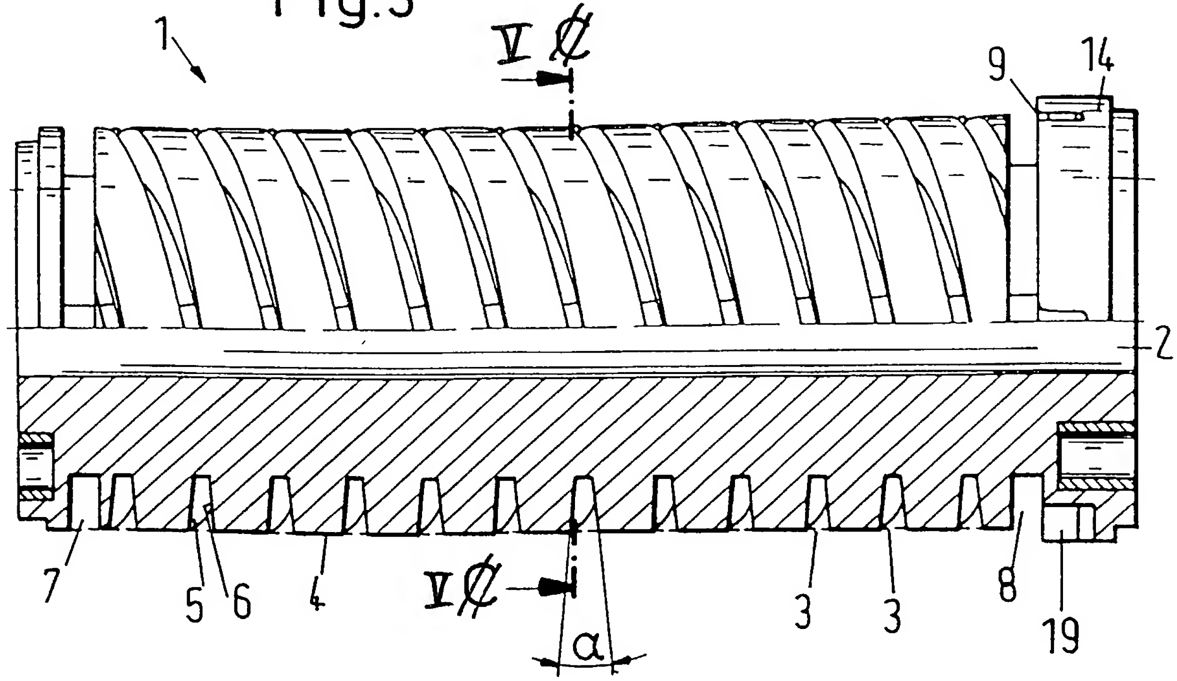
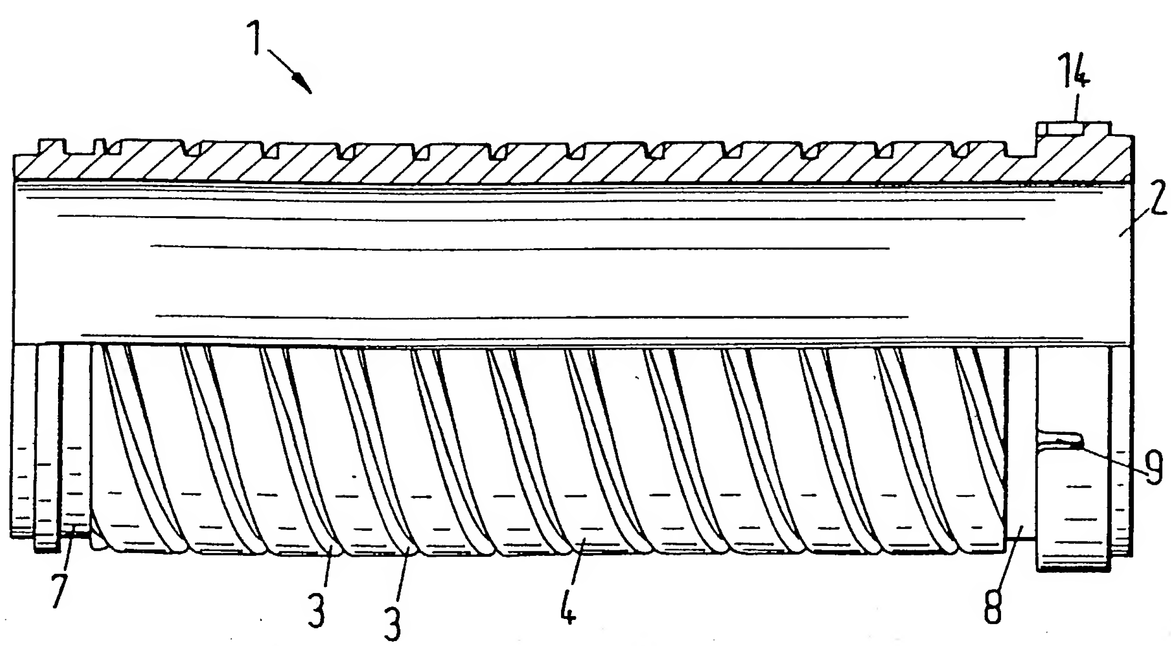


Fig.4



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73,406

Cylinder for a Twin-Screw Extruder

Description

This invention concerns a twin-screw extruder according to the main concept of patent claim 1.

Screw extruders are used in many ways in the processing of plastics. In order to provide a work result of qualitatively high value, it is important that the plastic being processed be extruded in a manner that is as uniform as possible and within an optimal temperature range. The cylinder of the extruder, which is provided with a hole corresponding to the dimensions of the screw unit, which form the extrusion space for the plastic to be processed, is therefore generally pulled through channels in its wall, through which a tempering medium that is capable of flowing (as a rule for cooling, but also for heating) can be fed.

A cylinder for a twin-screw extruder is known from EP 00 42 466 A1, which consists of two coaxial parts, one fed into the other, namely an inner cylinder part, which has a double hole (extrusion space) for the twin-screw unit, shaped like spectacles, and an outer, hollow-cylinder mantle, which lies close to and surrounds the inner cylinder part and with respect to which the forces exerted by the extrusion pressure fulfill a carrier function. In this case, both the inner

cylinder part and the hollow-cylinder mantle are pulled through channels running in the longitudinal direction of the cylinder for a tempering medium. In order to be able to cool the extrusion space as effectively as possible also in the region of its thickest wall, namely in the region of the spandrel of the spectacle-shaped hole, cooling channels are arranged in the inner cylinder part in the region of this spandrel. In the nearby region of the planes through the longitudinal axes of the twin-screw unit, cooling of the extrusion space occurs mainly through the cooling channel of the hollow-cylinder outer mantle. This means that, for this, the heat from the inner cylinder part must flow over into the hollow-cylinder mantle. This is prevented by the separation seam between the two parts of the cylinder. Therefore, the use of heat-conducting pastes has been recommended, with greater or less success, in order to improve the heat transfer in this critical region. From the viewpoint of manufacturing technology, this solution has the disadvantage that cooling channels must be made in both parts of the cylinder. Also, the hollow-cylinder mantle cannot also be used as the inner cylinder of a single-screw extruder, since the cooling channels are concentrated on only one part of its circumference.

Another structure for the cylinder of a twin-screw extruder is known from DE 26 59 037 C3, which likewise consists of an

inner cylinder part and a hollow-cylinder mantle. For cooling of the extrusion space, a cooling channel is provided that has a course similar in principle to a screw line. The cooling channel is arranged in the region of the surface separating the inner cylinder part and the hollow-cylinder mantle. In this case it is composed of partial pieces of different shapes, in the following manner: on the upper side of the inner cylinder part, grooves are etched at equal distances from one another, with vertical walls, in such a way that the bottoms of the grooves are all parallel to the longitudinal axes of the planes in the twin-screw unit, the direction with respect to the longitudinal axis is chosen, however, at exactly the opposite angle. The arrangement of the upper and lower grooves and their distances are selected in such a way that their ends overlap pair-wise. In order to connect the overlapping ends in view of joining the tempering media, sickle-shaped connecting grooves are etched on the inner surface of the hollow-cylinder mantle. The cooling channels generated in this manner, which run like screw lines, have the advantage that the tempering medium in the region of the spandrel of the spectacle-shaped hole is brought to the extrusion space relatively densely. From the viewpoint of manufacturing technology, creating of the cooling channel still requires a comparably high expense, since not only must the grooves be etched on the upper and lower side of the inner cylinder part, but etching work is

also necessary on the inner side of the hollow-cylinder mantle. In addition, the hollow-cylinder mantle produced in this way is only usable for the corresponding inner cylinder part of a twin-screw extruder, but not as an inner cylinder part for a single-screw extruder.

Another solution for a cylinder of a twin-screw extruder that has an inner cylinder part and a hollow-cylinder mantle surrounding it is known from DE-OS 20 61 700, which is the overall state of the art. The wall of the inner cylinder part is cut through with numerous adjacent grooves above, below, and to the side of the spectacle-shaped hole for the twin-screw unit. The bottoms of these grooves run in straight-line segments or in arcs in such a way that the remaining wall to the extrusion space has approximately the same thickness everywhere. This requires a correspondingly high manufacturing cost. In order for connect the individual grooves into a channel running like a screw line for the cooling medium, the grooves on the bottom side of the inner cylinder part are connected together in such a way that three partial pieces, two of which run perpendicular to the longitudinal axis of the twin-screw unit and a middle one is directed at an angle to the longitudinal axis, in such a way that an overflow from one winding of the cooling channel to the next results. This in turn leads to an increase in manufacturing costs for the inner cylinder part. Since walls

(bridges) remaining between the individual windings of the cooling channel should serve to transfer loads to the hollow-cylinder mantle that surrounds the inner cylinder part, the bridges, which have relatively small dimensions, arranged above and below the spectacle-shaped hole of the extrusion space and were originally especially high, are etched on a surface parallel to the plane of the twin-screw unit. On this etched surface, the bridges are each made in a cylinder section formed from filling material on the upper side and on the lower side of the inner cylinder part, the outer contour of the cylinder section corresponding to the hollow-cylinder mantle. These cylinder sections cover the individual windings of the cooling channels from top to bottom. In this way, the cross-section of the cooling channel, when viewed from above the circumference, remains approximately uniform in size. Although this known construction makes it possible to use a hollow-cylinder mantle with a smooth inner surface, it not only requires an increased manufacturing cost to generate the individual winding of the cooling channel, but also an additional cost for creating the two cylinder segments.

The task of the present invention is to develop a cylinder according to the overall concept of patent claim 1 for a twin-screw extruder so that the manufacturing cost required remains as small as possible, whereby an especially uniform and effective tempering of the extrusion space is to be

provided. In addition, the hollow-cylinder mantle of the cylinder should be usable universally, as far as possible. Specifically, it should be usable for single-screw as well as twin-screw extruders.

This task is solved by the characteristics given in patent claim 1. Advantageous further developments of the invention are given in the dependent subclaim.

The present invention starts from a twin-screw extruder with a cylinder, which surrounds the twin-screw of the extruder, forming an extrusion space. The cylinder is surrounded in turn by a hollow-cylinder mantle, the inner surface of which is made smooth. On the outer side of the cylinder, at least one channel is built in, which extends in the form of a screw line in the longitudinal direction of the cylinder and can be connected for a tempering medium that can flow. In contrast to the overall state of the art, in which the channel in the form of a screw line is closed in the radial direction through a part of the cylinder by separately produced cylinder sections, while the corresponding connection in the other regions of the circumference are closed directly by the hollow-cylinder mantel, in the cylinder constructed according to the invention, it is envisioned that the channel(s) is/are closed over the entire circumference by the hollow-cylinder mantel itself. Thus no components are needed that correspond

to the cylinder sections from the overall state of the art. A significant cost reduction for the cylinder according to the invention results from the circumstance that the channel(s) for the tempering medium are generated by a winding vortex. This involves an especially simple manufacturing process that can be implemented by placing the piece under tension and generating channels with a completely uniform screw-line course, which is a great advantage for the flow-through of the tempering medium. The channel(s) thus have no sudden kinks or other flow obstacles.

In principle, the cylinder can be provided with a single channel with a screw-line shape. In most cases, however, it will be appropriate, such as with multiple windings, to provide several channels next to one other. Advantageously, there will be three or four such channels running parallel to one another on the outside of the cylinder. The pitch of the channel(s) will generally be kept constant over the length of the cylinder. In individual cases, however, it may be reasonable to change this pitch, in order to affect the dwell time of the tempering medium in a particular section of the cylinder along its longitudinal axis. By selecting a large pitch, the tempering medium can be fed in the direction in which the extruder moves or even in the opposite direction, as needed.

In many cases, it is advantageous to provide a rectangular shape for the channel(s). The depths of each channel in the radial direction, i.e. its cycle depth, can remain constant over the circumference of the cylinder. The advantage is that the wall thickness of the extrusion space is likewise constant over the circumference and thus the flow patch through the wall of the extrusion space for the heat to be transported -- seen over the circumference -- likewise remains constant. In regard to the arrangement of the individual windings of the channel(s) of the cylinder, it has turned out to be appropriate, especially with channels with a rectangular cross-section and a uniform cycle depth, that the width of the channel(s)(measured in the longitudinal direction of the cylinder) be set at in the region of the 0.7 to 1.2 times the thickness of the bridges of the channels. The bridges are dimensioned in such a way that they provide directly an adequate support for load transfer to the hollow-cylinder mantle, without special components such as are needed in the cylinder section according to DE-OS 2,061,700.

In the embodiment of the invention, a design of the channel(s) with various cycle depths is provided over the circumferences. In this case, the cycle depth is selected as small as possible in the regions where the original wall thickness of the cylinder, i.e. before the channels are made, is smallest. The greatest cycle depth is provided in the

regions in which the original wall thickness is greatest. The transition between the largest and smallest cycle depths run completely smoothly and uniformly, because of the winding-vortex process envisioned for producing the channels. For a twin-screw extruder, a cylinder is recommended in which the largest cycle depth of the channel is about 3 to 5 times the smallest cycle depth, especially preferably about 4 times. In this case it may be appropriate to select something other than a rectangular shape and provide a conic expansion in the outward direction for the cross-section in the radial direction. The width of each channel thus increases in the outward direction. This means that the side surfaces of each channel in the section through the length of the cylinder do not run parallel, but include an angle, α. This angle, α, is advantageously in the range of 8-15°, especially about 10°. With a conic shape for the cross-section of the channels, it is recommended that the average thickness of the bridges between each pair of adjacent windings in the channel(s) be selected in the range of 1.5 to 4 times the average width of the channel(s). An average bridge width of about 2.5 times the average channel width is preferred.

In order to feed the tempering medium in and out in the simplest possible way, it is advantageously provided that in cylinders with several channels running parallel to one another, a groove going around the cylinder be made in the

region of the front ends of the cylinder. The connections for feeding the tempering medium in and out are in this case arranged in a corresponding manner in the hollow-cylinder mantle in the region of one of the two grooves. In this way, the grooves thus receive the function of a distributor or collector for the individual channels, so that the tempering medium can be fed in and out as needed with a single line connection.

Beyond the low manufacturing costs, the cylinder according to the invention provides an effective heat exchange, since through the effect of the cycle depth of the channels the flow path for the heat can be reduced within the wall of the cylinder as needed. Increased resistances to the flow of heat due to separation surfaces between individual components are avoided in the invention. For a given cylinder diameter, it makes no difference for the design of the hollow-cylinder mantle surrounding the cylinder how many channels, with which cross-section shape, and which cycle depths are provided in the cylinder.

In the following, the invention will be explained in more detail by means of the embodiment examples shown in the drawing. Here:

Fig. 1 shows a perspective view of a cylinder according to the invention,

Fig. 2 shows a view from the right front side of the cylinder according to Fig. 1,

Fig. 3 shows a longitudinal section along line A–A in Fig. 2, presenting a view of the upper half,

Fig. 4 shows a longitudinal section along line B–B in Fig. 2, presenting a view of the lower half,

Fig. 5 shows a cross-section along line C–C in Fig. 3,

Fig. 6 shows a view of the left front side of the cylinder according to Fig. 1, and

Fig. 7 shows the cylinder according to Fig. 1 inserted into a cylindrical mantle in a partial side view and partial longitudinal section.

The cylinder 1 shown in perspective in Fig. 1 is provided for an extruder with a twin-screw unit and therefore has two partially overlapping holes for the two meshed screws (not shown), whereby the holes together form an extrusion space 2 with a cross-section in the shape of spectacles. In the region of the left front side of the cylinder 1, an application flange 14 is provided, which, as can be seen especially in Figs. 3 and 4, has a diameter only slighter larger than that of the cylinder 1 in the rest of its length. On the outer side of the cylinder 1, a number of windings of channels 3 are provided in the shape of a screw line, between

which bridges 4 stand as separation walls.

The implementation of the channels 3 can be seen in detail from the section views of Figs. 3 through 5. The axial longitudinal section in Fig. 3 along line A—A according to Fig. 2 shows that the channels 3 each have side walls 5, 6 that are at an angle, α, to each other, so that the channel cross-section expands conically outward in the radial direction. The average width of the bridges 4 between the individual windings of the channels 3 is about 2 to 2½ times the average width of the channels 3(measured in the longitudinal direction of the cylinder 1). It can be seen from the cross-section made along line C—C according to Fig. 3, which is shown in Fig. 5, that a total of four channels are involved here, which extend at equal distances from each other in the shape of a screw line over the essential part of the axial length of the cylinder 1. It can also be seen from Fig. 5 that the cycle depth of the channels 3, i.e. their depth in the radial direction of the cylinder 1, is not constant over the course of the circumference of the cylinder 1, but changes uniformly in the region near the planes through the longitudinal axis of the extrusion space 2, in which the cycle depth in the channels 3, indicated by h_2, is the greatest. The uniform change of the cycle depth between the largest value, h_2, and the smallest value, h_1, results in a simple manner from a corresponding setting of the process

parameters used in the winding vortex process used in producing the channels 3. Whereas Fig. 3 shows a side view and a longitudinal cross-section in the region of the smallest cycle depth, h_2, in Fig. 4 a longitudinal section along line B-B is shown, rotated by 90° i.e., in the region of the smallest cycle depth. By varying the cycle depth over the circumference of the cylinder 1, it is achieved that extreme differences in heat flow between the extrusion space 2 and the channels 3 over the circumference of the cylinder 1 are greatly reduced. Each of the four channels 3 opens into a groove 7 or 8 that runs around and near to the front end of the cylinder 1, which has the function of a distributor or a collector for the tempering fluid to be fed through the channels 3.

In Fig. 6, a view of the front side of the cylinder 1 is shown with the application flange 14. As can also be seen in Fig. 2, holes to accept adjusting bolts 15 are provided in the region of the greatest wall thickness, which are shown in detail in the side view of Fig. 7. Fig. 7 shows the structure of a complete cylinder 11, consisting of the cylinder 1 and the associated hollow-cylinder mantel 10, in halves in the longitudinal section. The hollow-cylinder mantle 10, which has connecting flanges 17, 18 on each of its two ends, is made smooth on its inner surface. Only in the region of the application flange 14 does it have a section with an enlarged

inner diameter, which corresponds to the outer diameter of the application flange 14 of the cylinder 1, so that the application flange 14 can be applied in this section and be held as a stop against shifts by the cylinder 1 in the longitudinal direction. The inner diameter of the hollow-cylinder mantle 10 corresponds to the outer diameter of the bridges 4 of the cylinder 1, which is thus embedded as a "moist bushing" in the hollow-cylinder mantle 10, so that the individual windings of the channels 3 are closed in the radial direction toward the outside. There is a radial hole through the connection surfaces 17, 18 for feeding the intake 12 and the outlet 13 of the tempering medium, which end in the region of the circumferential grooves 7, 8. The connection between the circumferential groove 8 and the outlet 13 is not as direct as between the circumferential groove 7 and the intake 12. Rather, the connection is made in this case through an indentation 19 in the application flange 14. The tempering medium can thus flow through the intake 12 in the circumferential groove 7, which functions as a distributor, and from there into the four channels 3 in the shape of a screw line. After flowing through the channels 3, the tempering medium arrives at the circumferential channel 8, which functions as a collector and is there again removed through the indentation 19 and the line 13 from the full cylinder 11. During the flow through the channels 3, an effective heat exchange takes place between the tempering

medium and the extrusion space 2.

Because the cylinder 1 cannot be turned with respect to the hollow-cylinder mantle 11, stop grooves 9 are provided in the region of the circumference of the application flange 14, into which pin screws 16 make contact through corresponding holes made radially through the connection flange 18. Through the connection flanges 17, 18, several full cylinders 11 can be connected together. In this case it is obviously possible, with a hollow-cylinder mantle 10 of unchanged construction with respect to the channels, to use various cylinders 1, in order to meet optimally the different needs for heat exchange (cooling or heating) along the extrusion space.

With the cylinder according to the invention, a very cost-favorable solution that is very effective in regard to the technical requirements is offered for the process-oriented tempering of a screw extruder.

List of references

1	cylinder
2	extrusion space
3	channel
4	bridge
5	side surface of the channel
6	side surface of the channel
7	circumferential groove
8	circumferential groove
9	stop groove
10	hollow-cylinder mantle
11	full cylinder
12	intake
13	outlet
14	application flange
15	adjustment bold
16	pin screws
17	connection flange
18	connection flange
19	indentation
α	side-wall angle
h_1	smallest cycle depth
h_2	largest cycle depth

Patent claims

1. A cylinder for a twin-screw extruder, where the cylinder (1) surrounds a twin screw of the extruder, forming an extrusion space (2) and is in turn surrounded by a hollow-cylinder mantle (10), which has a smooth inner surface, where on the outside of the cylinder (1) at least one channel (3) is made in the shape of a screw line in the longitudinal direction of the cylinder (1), which can be connected to an intake and outlet (12, 13) for a tempering medium that is capable of flowing, and can be closed, at least over part of the circumference of the cylinder (1), in the radial direction by the hollow-cylinder mantle (10),
characterized by the fact
that the channel(s)(3) are made in the cylinder (1) by a winding-vortex process and the channel(s)(3)are closed by the hollow-cylinder mantel (10), that the cycle depth of the channel(s) (3) in the radial direction changes over the circumference of the cylinder (1) in such a way that it is greatest in regions where the original wall thickness of the cylinder (1) is greatest, and that it is smallest in the regions where the original wall thickness of the cylinder (1) is also smallest.

2. A cylinder according to claim 1, characterized by the fact that for a winding of several cycles, several channels (3) are provided, especially three or four adjacent channels (3).

3. A cylinder according to one of claims 1-2, characterized by the fact that the pitch of the individual windings in the channel(s) (3) is constant in the longitudinal direction of the cylinder (1).

4. A cylinder according to one of claims 1-3, characterized by the fact that the channel(s) (3) has/have an essentially rectangular cross-section.

5. A cylinder according to one of claims 1-4, characterized by the fact that the width of the channel(s) (3) in the longitudinal direction (1) is 0.7 to 1.2 times the thickness of the bridge (4) between each pair of directly adjacent windings of the channel(s) (3).

6. A cylinder according to one of claims 1-5, characterized by the fact

that the greatest cycle depth is about 3 to 5 times, especially about 4 times the smallest cycle depth.

7. A cylinder according to one of claims 1-3 or 5-6, characterized by the fact that the width of the channel(s)(3)expands in the radial direction toward the outside.

8. A cylinder according to claim 7, characterized by the fact that the side surfaces (5, 6) of the channel(s)(3) include an angle (α) in the range of 8-15°, especially an angle of about 10°.

9. A cylinder according to one of claims 1-8, characterized by the fact that the average thickness of the bridges (4) between two directly adjacent windings of the channel(s) (3) is 1.5 to 4, especially 2.5 times the average width of the channel(s)(3).

10. A cylinder according to one of claims 1-9, characterized by the fact that the channels (3) in the region near the front end of the cylinder (1) each open into circumferential grooves (7, 8) and the connections for the intake and outlet (12, 13) of the tempering

medium each open into one of the two grooves (7, 8), on the hollow-cylinder mantle (10).

Abstract

The invention concerns a cylinder for twin-screw extruder, where the cylinder (1) surrounds a twin screw of the extruder, forming an extrusion space (2) and is in turn surrounded by a hollow-cylinder mantle (10), which has a smooth inner surface, where on the outside of the cylinder (1) at least one channel (3) is made in the shape of a screw line in the longitudinal direction of the cylinder (1), which can be connected to an intake and outlet (12, 13) for a tempering medium that is capable of flowing, and can be closed, at least over part of the circumference of the cylinder (1), in the radial direction by the hollow-cylinder mantle (10). In this case, at least one channel (3) is made in the cylinder (1)by a winding-vortex process and the channel(s) (3) [are] closed by the hollow-cylinder mantle (10). The cycle depth of the channel(s) (3) in the radial direction changes over the circumference of the cylinder (1) in such a way that it is greatest in regions where the original wall thickness of the cylinder (1) is greatest, and that it is smallest in the regions where the original wall thickness of the cylinder (1) is also smallest.

Figure 1 attached.

10/069218

Fig.1

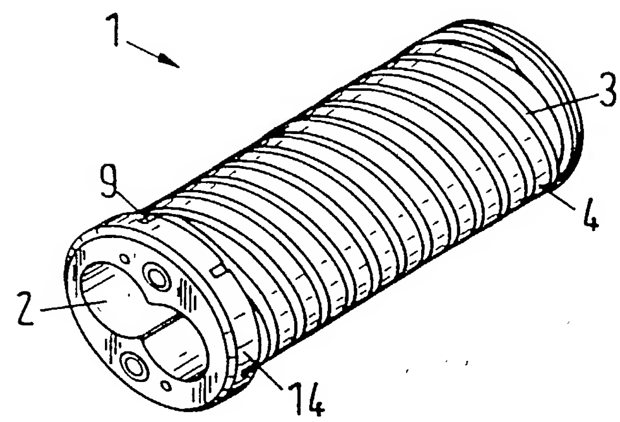


Fig.2

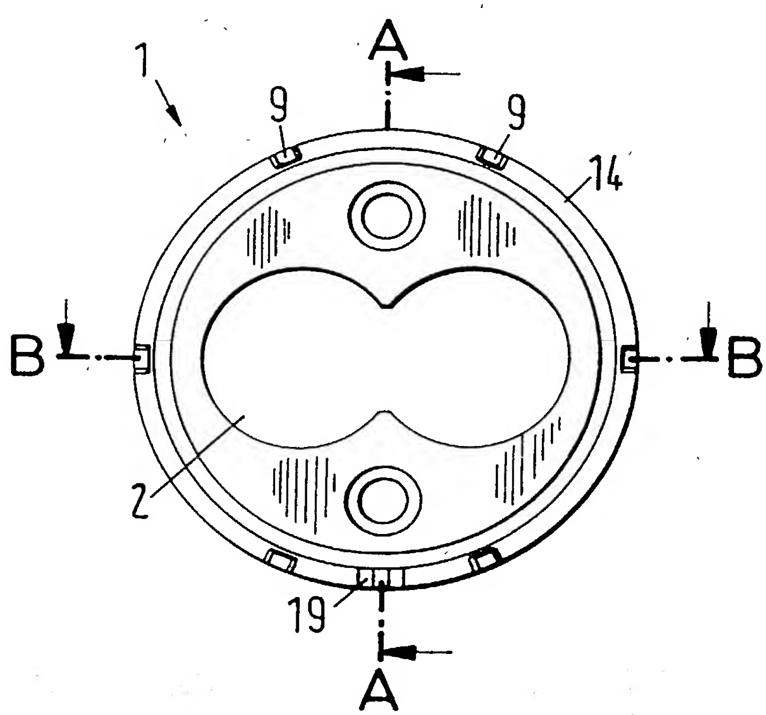


Fig.3

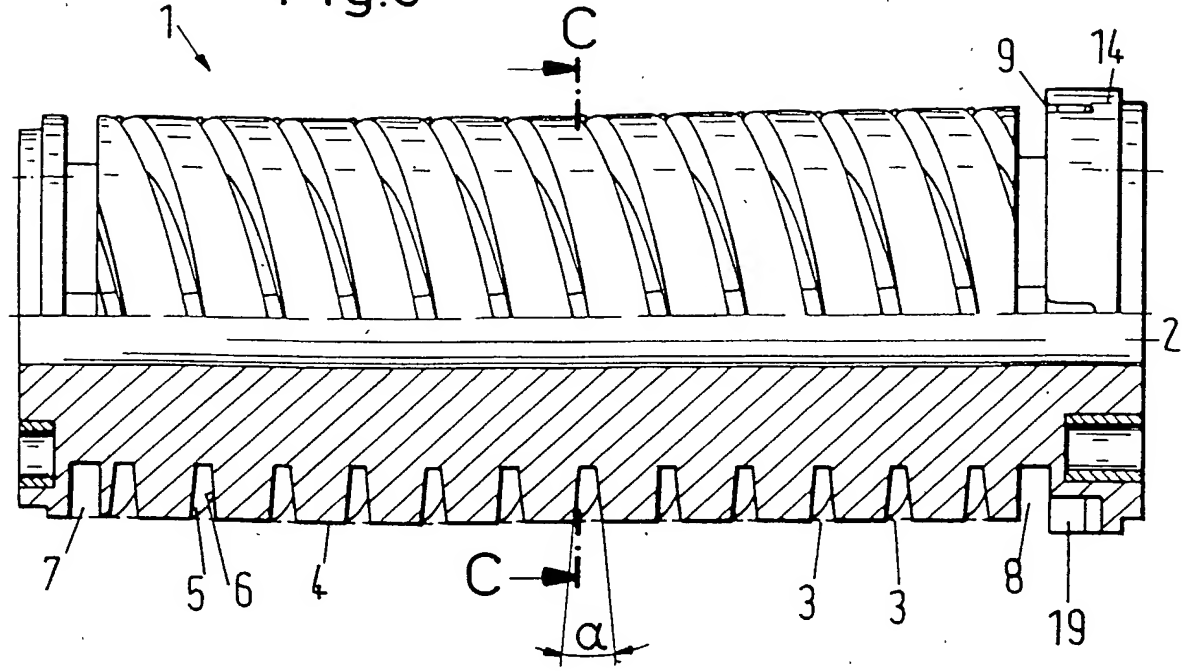


Fig.4

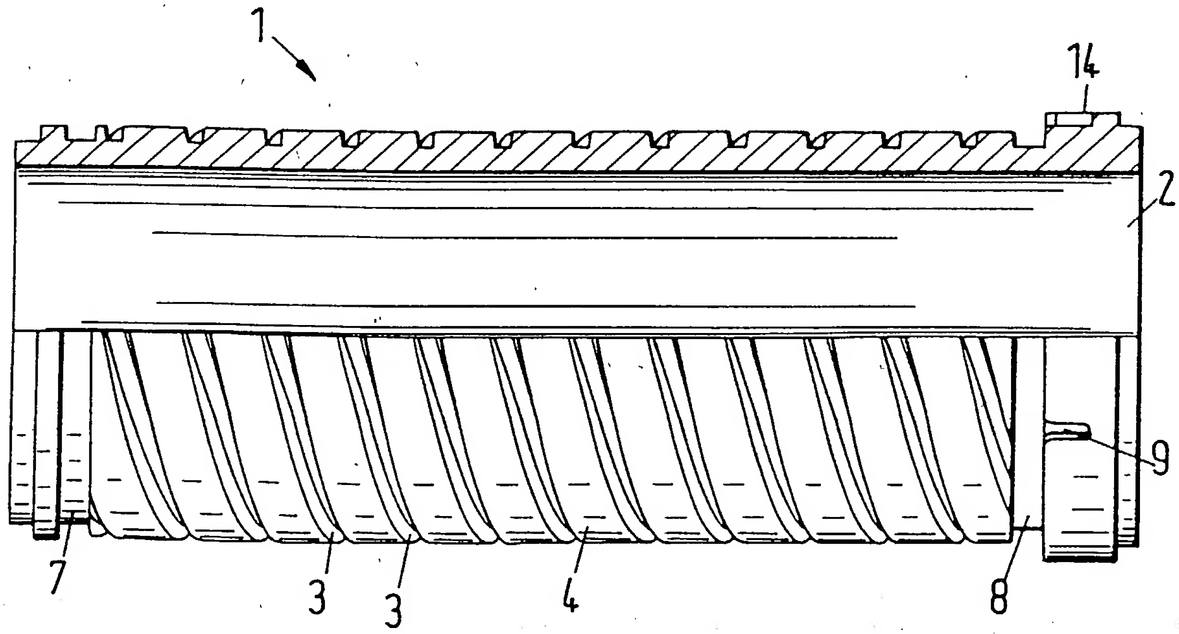


Fig.5

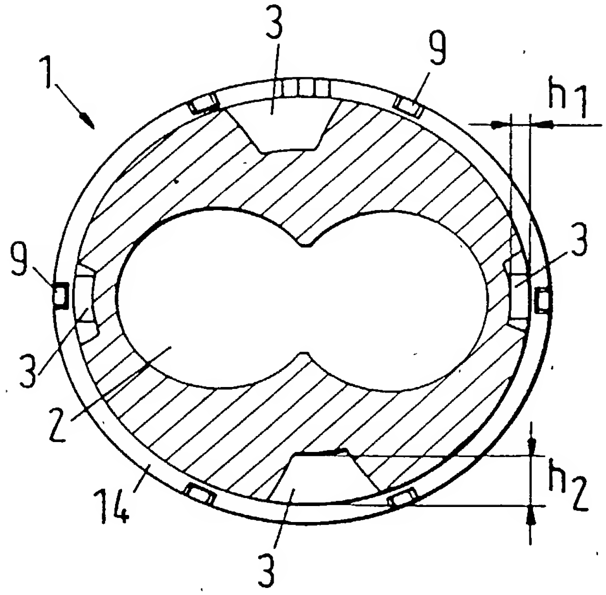


Fig.6

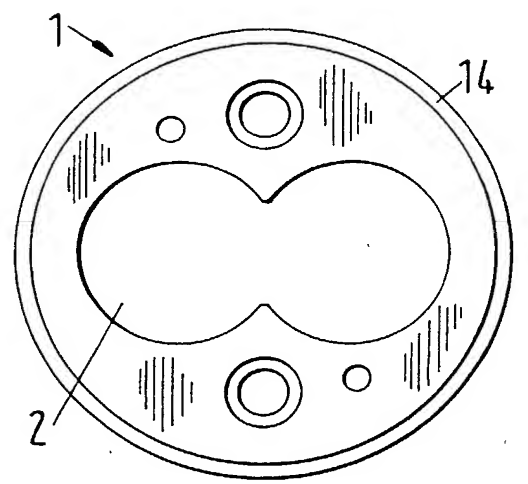
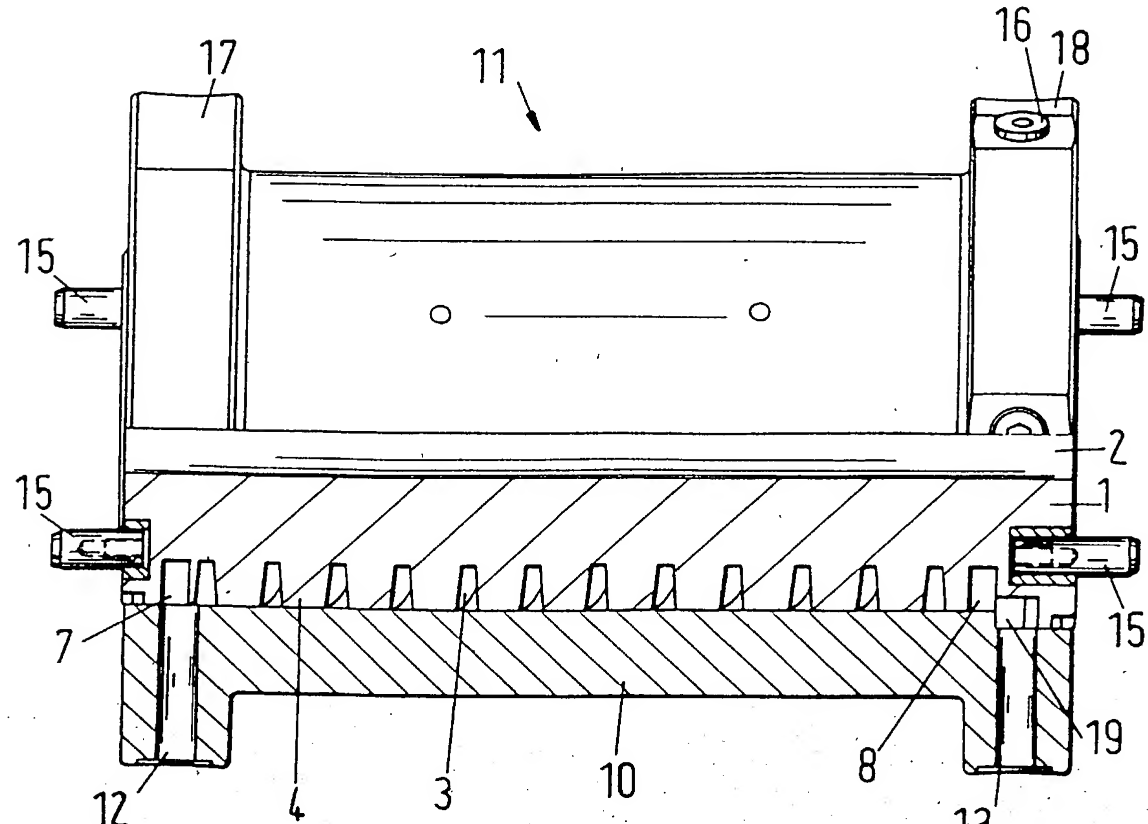


Fig.7



10 Rec'd PCT/PTO 06 JUN 2002

COMBINED DECLARATION FOR PATENT APPLICATION AND POWER OF ATTORNEY Includes Reference to PCT International Applications	Attorney's Docket No.5067-19PUS

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

CYLINDER FOR A TWIN-SCREW EXTRUDER

the specification of which (check only one item below)

[ ] is attached hereto

[ ] was filed as United States application

Serial No.

on

and was amended

on _ (if applicable).

[x] was filed as PCT international application

Number PCT/DE00/02896

on 22 August 2000

and was amended under PCT Article 19

on ____________ (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the patentability of the application in accordance with Title 37, Code of Federal Regulations, §1.56(a).

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate or of any PCT international application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed.

PRIOR FOREIGN/PCT APPLICATIONS AND ANY PRIORITY CLAIMS UNDER 35 U.S.C. 119:

Country (if PCT, indicate "PCT")	Application Number	Date of Filing (day, month, year)	Priority Claimed Under 35 U.S.C. 119	
Germany	199 41 160.3	24 August 1999	[x] YES	[ ] NO
PCT	PCT/DE00/02896	22 August 2000	[x] YES	[ ] NO
			[ ] YES	[ ] NO
			[ ] YES	[ ] NO
			[ ] YES	[ ] NO
			[ ] YES	[ ] NO

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Combined Declaration for Patent Application and Power of Attorney (Continued)
(Includes Reference to PCT International Applications)

Attorney's Docket
5067-19PUS

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) or PCT international application(s) designating the United States of America that is/are listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in that/those prior application(s) in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which occurred between the filing date of the prior application(s) and the national or PCT international filing date of this application:

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U.S. APPLICATIONS			STATUS *(check one)*		
U.S. APPLICATION NUMBER		U.S. FILING DATE	PATENTED	PENDING	ABANDONED
PCT APPLICATIONS DESIGNATING THE U.S.					
PCT APPLICATION NO.	PCT FILING DATE	U.S. SERIAL NUMBERS ASSIGNED *(if any)*			
PCT/DE00/02896	22 August 2000			x	

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith (*List name and registration number*)

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under §1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

SIGNATURE OF INVENTOR 201	SIGNATURE OF INVENTOR 202	SIGNATURE OF INVENTOR 203
Michael Schling		
DATE 02/22/2002	DATE	DATE

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